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FARM PRACTICE IN THE COLUMBIA BASIN UPLANDS

BY

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., March 28, 1907.

SIR: I have the honor to transmit herewith a description of the system of farm management employed in the uplands of the Columbia Basin, prepared by Mr. Byron Hunter, Assistant Agriculturist in the Farm Management Investigations of this Bureau, and recommend that it be published as a Farmers' Bulletin.

This bulletin is to be issued jointly by the United States Department of Agriculture and the Oregon and Washington agricultural experiment stations.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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FARM PRACTICE IN THE COLUMBIA BASIN UPLANDS.

INTRODUCTION.

Men can usually be found in different localities, here and there, who stand out as the most successful farmers of their respective communities. Intelligently meeting the difficulties confronting them, these men work out the problems of tillage and crop production in a satisfactory manner. By studying and comparing the methods of a large number of such men a vast amount of valuable information can be acquired in a comparatively short time that would require years of patient, intelligent labor to glean from individual experience.

During the three years the writer has had charge of farm management investigations in the Pacific Northwest, considerable time has been spent in studying farm practice in the Columbia Basin. Representative localities have been visited, and, so far as possible, the methods of the most successful farmers have been studied. The principal objects in undertaking this study were (1) to ascertain what methods of tillage are in actual use by the farmers of the region, together with the relative merits of the different methods, and (2) to determine, if possible, the localities and conditions under which each of the leading varieties of wheat succeeds best. In making this detailed study the writer had the advantage of being quite familiar with conditions in the beginning, having lived in the region studied for more than twenty years.

The methods of farm practice discussed in the following pages will doubtless be applicable to other sections of the country of similar character. For this reason a description of the region studied is given.

DESCRIPTION OF THE REGION.

The area covered in this study includes a portion of each of three States—Idaho, Oregon, and Washington. It consists of the wheat-growing lands of the Columbia Basin. The area is almost entirely surrounded by mountains. The Cascade Mountains lie to the west; the Bitterroot and the Coeur d'Alene mountains to the east; the

Okanogan Highlands to the north, and the Blue Mountains to the southeast.

Practically the whole of the area is covered by an immense mass of basalt, the result of a series of lava overflows. Subsequent to the last great overflow a large lake covered a portion of the area in north-

FIG. 1.—Relief map of parts of Oregon and Washington, showing the Columbia Basin.

ern Oregon and central Washington. Into this lake streams carried sand and mud, and volcanoes threw into it great quantities of dust and ashes. Because the deposits of this lake were first studied along John Day River in Oregon it is known as Lake John Day. In some localities the deposits of this prehistoric lake were hundreds of feet

in thickness. Since the deposition of these sedimentary beds, the elevation and folding of the underlying Columbia basalt have given the country its present topography. Much of the sediment has also been removed by erosion, and streams have cut deep channels through the basalt, which, though very hard, rapidly disintegrates when exposed to air and water. The accompanying relief map (fig. 1) will give the reader a general idea of the topography of the country.

With the exception of the valleys along the streams, practically the entire area included in these studies consists of one vast expanse of undulating, treeless hills. In some localities the inclines are

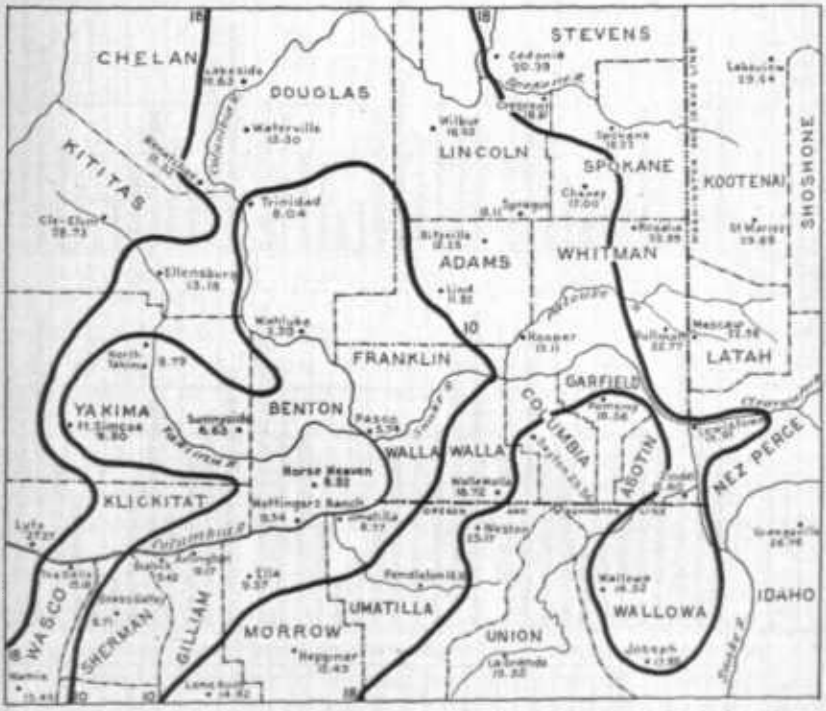

FIG. 2.—Map showing the rainfall at points in and near the Columbia Basin, expressed in inches.

gentle, but the general surface is quite rolling. Near the mountains it is often steep. The elevation varies from a few hundred feet along the Columbia River to as much as 3,000 feet in parts of the eastern portion of the region.

The accompanying rainfall map (fig. 2), prepared from the reports of the United States Weather Bureau, shows the average annual rainfall to be less than 6 inches at points along the Columbia River. This gradually increases with the elevation and distance from the river until an annual rainfall of 23 or 24 inches is reached in the foothills of the Blue and the Bitterroot mountains.

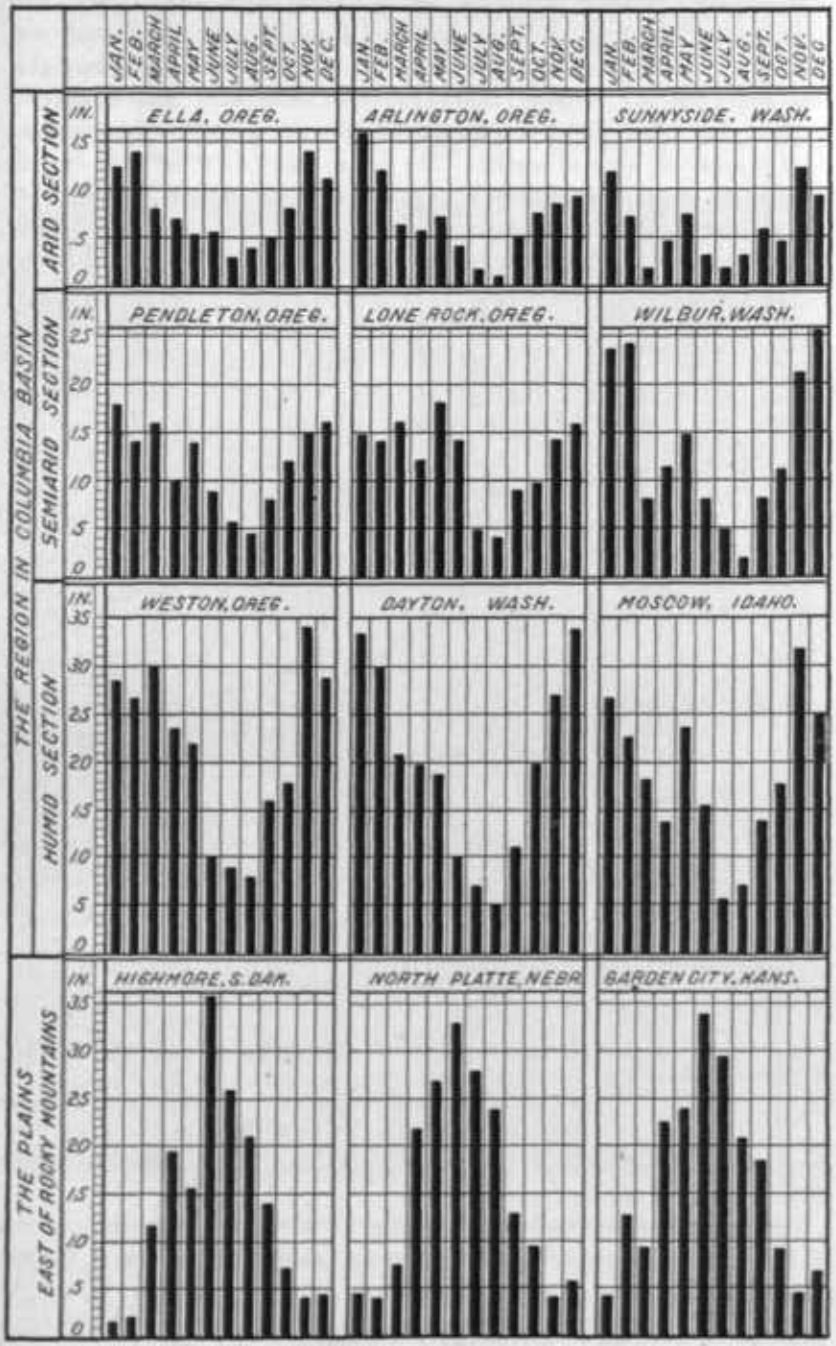

FIG. 3.—Diagrams showing the monthly distribution of rainfall at points in the Columbia Basin compared with points on the Great Plains. The monthly rainfall in inches is shown by heavy vertical lines.

The average monthly rainfall of the arid, semiarid, and humid sections of the Columbia Basin is shown diagrammatically in figure 3. In order that the reader may realize the striking difference between the type of rainfall of the Columbia Basin and that of the Plains region east of the Rocky Mountains, figure 3 also includes the average monthly rainfall of Garden City, Kans., North Platte, Nebr., and Highmore, S. Dak.

Near the Columbia River, where the rainfall is lightest, it will be seen that the dry season extends from March to October, inclusive. Even during the winter months the rainfall is very scant. Eastward from the Columbia River the dry season gradually decreases in length and severity. Near the Blue and the Bitterroot mountains the dry season is confined entirely to the summer months, while the rainfall is quite well distributed throughout the remainder of the year. It must be remembered that in the Columbia Basin the rains are seldom torrential. Although the general surface is rolling the soil washes very little.

SOILS.

There are two general types of soils in the Columbia Basin—residual and sedimentary.

The residual soil occupies practically the entire wheat-producing area of the region. It is mainly the result of the weathering and disintegration of the Columbia basalt, and is a very fertile soil. In the eastern portion of the region—the humid section—it consists of of a friable, dark-brown silt loam, with a depth ranging from a few inches to about 3 feet. The subsoil consists of a light-brown silt loam. It is heavier and more compact and plastic than the surface soil, and affords good storage for moisture during the dry season. As the rainfall decreases this soil becomes lighter. In the drier localities it is a light-gray silt loam, with a depth of 6 or more feet. Owing to its light, ashy nature it is known locally as volcanic ash.

The sedimentary soil is the result of sediment and volcanic material deposited in ancient Lake John Day. It occupies an area of low altitude along the Columbia River and its tributaries. There is no definite line of demarcation between this and the residual soil. Most of this sedimentary type of soil that is under cultivation is irrigated. The residual soils are at higher levels, and are not irrigated.

AGRICULTURAL HISTORY.

There are two distinct agricultural sections in the Columbia Basin. One of these consists of the valleys along the streams, where irrigation is practiced; the other, of the upland prairies, where crops are produced without irrigation. It is only with the latter type of farming that this bulletin is concerned.

By referring to the foregoing rainfall map it will be seen that the

central part of the Columbia Basin is exceedingly dry, while the eastern portion receives the heaviest annual rainfall. Because of these conditions settlements were first made in the eastern portion of the region, adjacent to the Blue and the Bitterroot mountains. When these first settlements were made it was thought that only a comparatively narrow belt of land adjacent to these mountains was of any value for farming. The remainder of the region was considered of value only for grazing purposes.

The first great impulse toward agricultural activity was felt from twenty-five to thirty-five years ago. Since the early settlement of these most humid sections the homesteader has gradually pushed agriculture back into the dry region, until now practically all of the land that will successfully produce crops without irrigation is under cultivation.

From the very beginning of the agricultural development of the region cereal crops have been grown almost exclusively. While alfalfa, timothy, corn, potatoes, fruit, etc., are produced in many parts of the country they all sink into insignificance when compared with the cereals, especially wheat.

The following table gives the acreage and production of the cereal crops in the Columbia Basin in 1899. Since that date large areas have been brought under cultivation and these figures would be materially increased in many of the drier counties were there complete data at the present time.

Acreage and production of barley, corn, oats, rye, and wheat in 1899, by counties.

Counties.	Barley.		Corn.		Oats.		Rye.		Wheat.	
	Acres.	Bushels.	Acres.	Bushels.	Acres.	Bushels.	Acres.	Bushels	Acres.	Bushels.
NORTHERN IDAHO.										
Idaho	9,137	272,280	46	1,280	2,355	73,920	98	2,280	10,940	230,446
Latah	5,505	177,810	588	12,610	10,030	349,361	22	480	63,770	1,584,490
Nez Perce	12,565	380,600	1,167	28,210	4,673	166,500	14	360	53,178	1,110,280
EASTERN OREGON.										
Gilliam	3,394	43,870	25	420	448	6,420	513	4,900	45,950	406,480
Morrow	6,201	76,650	18	340	590	9,720	1,632	11,070	43,389	381,350
Sherman	1,763	42,230	158	2,650	1,718	34,120	56	680	91,100	1,050,400
Umatilla (and Reservation)	14,249	429,660	666	13,820	2,005	54,980	491	5,840	193,577	3,494,370
Wasco	3,544	75,700	1,310	14,150	2,424	49,280	83	750	39,510	504,980
EASTERN WASHINGTON.										
Adams	922	26,730	198	3,200	849	23,430	209	2,457	88,025	1,203,670
Asotin	3,853	70,260	43	1,910	30	320	74	1,020	9,406	103,950
Columbia	26,273	811,160	1,644	34,800	2,625	102,610	25	300	44,720	1,083,300
Douglas	4,403	77,490	447	9,230	3,278	66,500	145	1,030	64,286	757,123
Franklin			33	370					152	4,040
Garfield	23,067	655,990	142	3,810	43	1,990	240	4,800	40,588	790,880
Kittitas	2,888	88,150	19	410	2,041	76,150	67	2,528	8,574	199,310
Klickitat	3,207	78,340	237	2,410	2,468	57,890	315	4,220	49,328	766,360
Lincoln	9,560	239,020	239	4,640	3,409	96,780	207	3,816	218,942	3,618,930
Spokane	3,375	87,220	208	4,100	16,759	455,218	119	1,380	89,768	1,580,880
Wallawalla	11,484	382,190	1,209	32,140	1,913	77,556	515	5,590	152,993	3,833,910
Whitman	28,537	992,660	1,950	37,260	26,352	1,023,890	125	2,220	280,194	6,415,220
Yakima and Benton	1,914	36,920	697	17,550	1,004	33,090	401	3,560	16,394	210,240

In the eastern portion of the region—that which was brought under cultivation first—a cereal crop was produced annually for several years. Little attention was given to the quality of the seed sown and the land soon became infested with weeds, especially with wild oats. The yield also decreased and it became necessary to summer fallow occasionally.

CROPPING SYSTEMS.

A very large portion of the territory under consideration now produces a crop of wheat every other year, the wheat alternating with summer fallow. This system is uniformly followed in all localities where the rainfall is scant.

Near the mountains, where the rainfall is heavier, two crops are usually grown each time the land is summer fallowed. After summer fallowing a crop of winter wheat is usually grown; the crop that follows this may be either barley, oats, or wheat. In some instances two spring crops follow the winter wheat—first a crop of barley and then a crop of spring wheat.

SOIL TILLAGE.

Soil tillage in the Columbia Basin divides itself into two phases—summer fallow tillage and tillage for spring crops. The former will be considered first.

SUMMER FALLOWING.

When questioned as to why they summer fallow, farmers usually give three reasons:

(1) To conserve moisture. Considerable wheat is now produced on each side of the Columbia River with as little as 8 or 9 inches of rainfall. Under such dry conditions the land is summer fallowed every other year in order to conserve the rainfall of one year for the use of the growing crop the next season. Even near the mountains, where the rainfall is heaviest, the conservation of moisture is usually given as the important reason for summer fallowing.

(2) To eradicate weeds. When farm land becomes foul with weeds the yield of cereal crops is greatly diminished. The weeds rob the growing crops of both moisture and plant food.

(3) The third reason for summer fallowing given by farmers is variable. It is usually about as follows: To get the soil into such condition that it will produce satisfactory crops.

It is well understood that while land is being fallowed certain changes take place within the soil that give it renewed fertility. As to just what these changes are and how they take place, there is yet much to learn. However, some of the conditions that are favorable

to these changes are known, and one of them is the maintenance of a moist, mellow, and thoroughly aerated surface soil. This condition, which is secured by plowing and frequent surface cultivation, is favorable to desirable bacterial life, the decomposition of the stubble and other organic matter that is incorporated into the soil by cultivation, and the production of available plant food.

Methods of Summer Fallowing.

In making the study previously referred to the following methods of summer fallowing were found in use in various parts of the country:

(1) **Late plowing with no cultivation.**—This method is practiced most frequently where there is considerable rainfall. The land is plowed just as late in the spring as possible, and no further cultivation is given. The object in plowing so late is to get all the pasture possible before plowing and to have the soil break up in a cloddy condition and become so dry before it is plowed that no weed seeds will germinate. If no weeds come many think that plowing is all the cultivation that is necessary. Cattle and horses, and in some instances sheep, are pastured on the summer fallow to keep the weeds down. Many do this class of work because they are farming two or three times as much land as can properly be handled with their equipment. Others profess to believe in it. If the rainfall is considerable and is well distributed through the growing season, good crops are often secured by this method. The advocates of this system say it is desirable to have the ground pass through the winter rough and cloddy in order that the depressions may catch the snow and rain water and prevent it from running off the surface. They further say that the soil runs together and becomes closely packed during the winter if it is finely pulverized, and that the lumpy condition secured by late plowing with no subsequent cultivation largely prevents this.

There are some serious objections to this system of summer fallowing. In the first place, it is not conducive to the conservation of moisture, to desirable bacterial life, and to the decomposition of the organic matter in the soil. Instead of being freed from noxious weeds the soil constantly becomes more foul. The average yield of wheat for a number of years when raised on land summer fallowed in this way is probably from 5 to 10 bushels less to the acre than that secured on well-tilled land. It is also claimed that the yield of the spring crop that follows the winter wheat grown on land summer fallowed in this way is also usually very low.

(2) **Early plowing with summer tillage.**—This is a very common method of summer fallowing and one that is practiced quite generally throughout the entire Columbia Basin. The plowing is done in the

spring as early as the ground is in good working condition. In practice the plowing is done as soon as the spring seeding is finished. Some follow the plow closely with the common tooth harrow. This settles the soil, pulverizes and dries the surface, and prevents the evaporation of a great deal of moisture. Others plow large areas before harrowing, permitting the soil to lie loose and open just as the plow leaves it. In this loose, open condition the air circulates through the soil too freely and dries it out very rapidly. Although it is not always done, it is usually the aim to do enough cultivating after plowing to control the weeds. Weeds are easiest destroyed just before or just at the time when they are coming through the surface of the ground. At this stage few implements are the equal of the common tooth harrow. After the weeds get too large for the harrow many farmers use the slicker (fig. 4), some form of a blade or knife weeder (figs. 5 and 7), or the disk harrow.

The slicker is used in many parts of the country. It is easily and cheaply constructed. It is usually about 12 feet wide, with four runners. The runners are made of 2 by 6 inch or 2 by 8 inch scantling. Boards are nailed on top of the runners. An iron rod five-eighths of an inch in diameter is fastened at the back end of the runners so that it drags in the soil 1 to 2 inches below the surface. A thin bar of steel as long as the width of the implement, about 2 inches wide and sharpened on the front edge, is sometimes used instead of the iron rod. The bar is bolted to the bottom of the back end of the runners. The weight of the driver who rides the implement causes the rod or knife to run just under the surface of the ground. When the rod clogs, it is dumped by lifting on the handles shown in the cut. It works very nicely when the soil is smooth, finely pulverized, and reasonably free from stubble and other trash. When the slicker is to be used, care should be exercised in turning the stubble under well. The same care is necessary in the use of the blade weeders. Keeping the blades or knives sharp is one of the chief secrets in the successful use of these weeders. Most farmers cultivate only to destroy the weeds. Some realize the importance of saving the soil moisture and aim to cultivate several times, especially after rains, for this purpose.

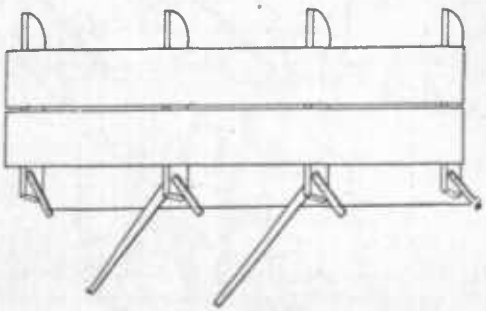

FIG. 4.—A slicker.

Several instances came under the observation of the writer during the autumn of 1906 where sufficient moisture had been retained by

this method of summer fallowing to germinate early-sown wheat and give good stands. There is no difficulty in doing this where the rainfall is heaviest, but the instances referred to were in localities having as little as 12 to 13 inches of rainfall.

(3) **Right lapping.**—Still another method of summer fallowing is that of right lapping. In parts of Adams and Franklin counties, Washington, the right-lap cutaway harrow (fig. 6) has been used for nine or ten years in cultivating summer fallow land. Where used this implement takes the place of the plow entirely.

As soon as the spring seeding is done the land to be summer fallowed is cultivated with the right-lap. If there is no seeding to be done, this first cultivation is given just as early as the condition of the soil will permit. During the first cultivation the disks of the right-lap run about 4 inches deep. It will be seen that weed seeds are not covered too deeply to germinate. By the time the first cultivation has been completed—from four to six weeks—a crop of weeds has usually made its appearance on the ground first gone over, and it is necessary to begin the second cultivation immediately. The disks being large and set at a considerable angle will run from 5 to 6 inches deep and turn the soil and cover weeds quite well. This second cultivation usually destroys a good crop of weeds.

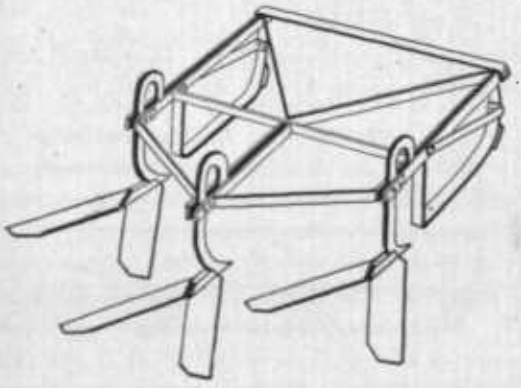

FIG. 5.—A weeder used principally in the Walla Walla Valley. By putting sections together it may be made as wide as desirable.

Usually two cultivations with the right-lap is all the cultivation given. However, if weeds come again, some use the right-lap the third time. Others use the harrow, slicker, or some other form of weeder. Very good results are obtained with this method, and it is certainly gaining in favor in the vicinity of Ritzville, Wash.

While the writer found no one who uses the tooth harrow immediately after right lapping, he is firmly of the opinion that a great deal of moisture could be saved in this way. The tooth harrow would settle the soil made loose and open by the disks of the right-lap cutaway harrow, and thus prevent the air from circulating too freely in the soil.

(4) **Disking before plowing.**—In parts of Klickitat, Wallawalla, Lincoln, and Whitman counties, Washington, and in Nez Perce County, Idaho, the following method of summer fallowing is coming into

use. It must be remembered that farmers are taking up this method independently of each other, and in localities that are separated by considerable distances. Just as early in the spring as the ground is in good working condition or as soon as the spring seeding has been completed, the land to be summer fallowed is disked. Some disk but once, while others double-disk and then use a smoothing harrow. Most farmers are ready to concede that the more cultivation given the better. By this surface cultivation a loose mulch is formed over the entire area to be summer fallowed much more quickly than it could be plowed. This saves much of the soil moisture, for evaporation always takes place rapidly in the spring from land that is packed by the winter rains. By the conservation of

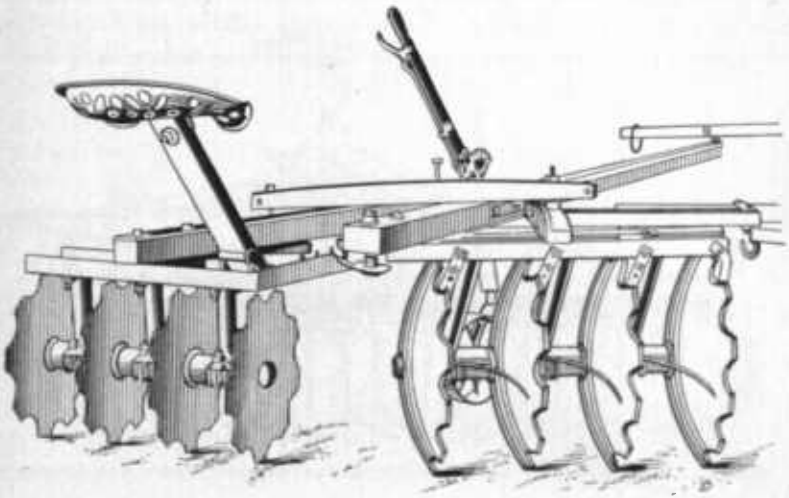

FIG. 6.—A right-lap cutaway harrow, used as a substitute for the plow.

moisture in this way, plowing may be delayed as much as four or five weeks.

In parts of Lincoln County, Wash., where early surface cultivation is practiced the plowing is usually done just as late as possible. No other cultivation is then given. The summer fallow often lies over until spring before it is sown to wheat, and it is thought best to have it pass through the winter in a rough and cloddy condition. The reason for this is the same as that given in discussing the first method of summer fallowing, viz, to keep the soil from running together so much during the winter.

In most other localities where disking in the early spring is practiced, the plowing is done from four to six weeks after the land has been disked and harrowed. The land is plowed in the order in which it is disked, and the harrow closely follows the plow. It is usually

the aim to do enough subsequent cultivation to keep the weeds subdued. Some realize the importance of cultivation to retain moisture, even though the land may be reasonably free from weeds. The writer knows of summer fallow land that received six and eight cultivations.

There is much to commend this method. The disking and harrowing in the early spring before plowing form a loose mulch on the entire area to be summer fallowed much more quickly than it could be plowed. This saves a great deal of moisture, for the land plowed last often becomes very dry when plowing is the first operation.

Most weed seeds germinate best if not covered very deeply. When lying on the surface of the ground, the plow often covers them so deeply that they do not germinate until turned up near the surface again by subsequent plowing. Early surface cultivation covers these seeds lightly and gives them a chance to germinate before the plowing

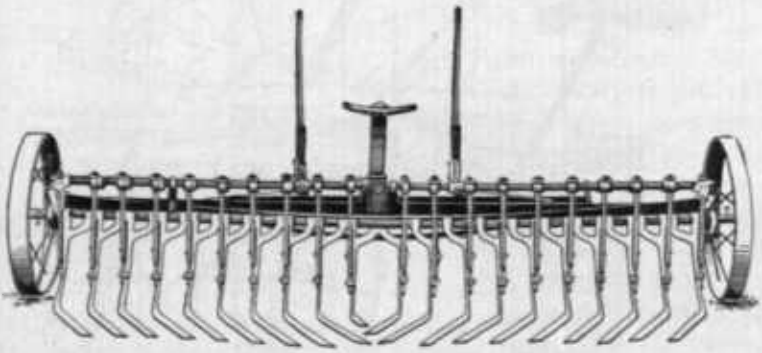

FIG. 7.—A weeder used in parts of eastern Oregon—an effective but expensive implement.

is done. The plow then destroys a crop of weeds, usually a heavy one. In this way practically all of the weed seed of the previous season's crop may be germinated before plowing and a clean surface soil turned under.

Early surface cultivation also causes the soil to plow more easily, and makes it more mellow and freer from clods. This is especially noticeable where roads have been made through the fields in the fall in hauling out the grain. Some farmers have formed the habit of harrowing these roads in the early spring, having learned its value accidentally by dragging the harrow to and from the fields. A great deal of trouble is experienced in plowing land covered with heavy stubble. Disking before plowing breaks the stubble down, partially covers it, and gets it into such condition that the plow turns it under much better than if the disking had been omitted. If the plowing is not delayed too long it turns up moist, mellow earth. The immediate use of the harrow is to settle and pulverize the soil. This condition

of the soil is favorable to the conservation of moisture and the germination of the weed seed turned up by the plow. Later cultivation destroys this crop of weeds and helps to retain moisture. The more moisture retained in the soil while fallowing the greater will be the decomposition of the stubble and other organic matter. Chemical action in the soil is also favored, thus providing more mineral plant food.

It will be seen that practically all of the soil turned by the plow can be cleaned reasonably well from weed seed. The thorough cultivation before plowing cleans the surface soil before it is turned under, and the subsequent cultivation cleans that which is turned up to the surface. In this way a clean seed bed is obtained. Men who are using this system say that land badly infested with wild oats

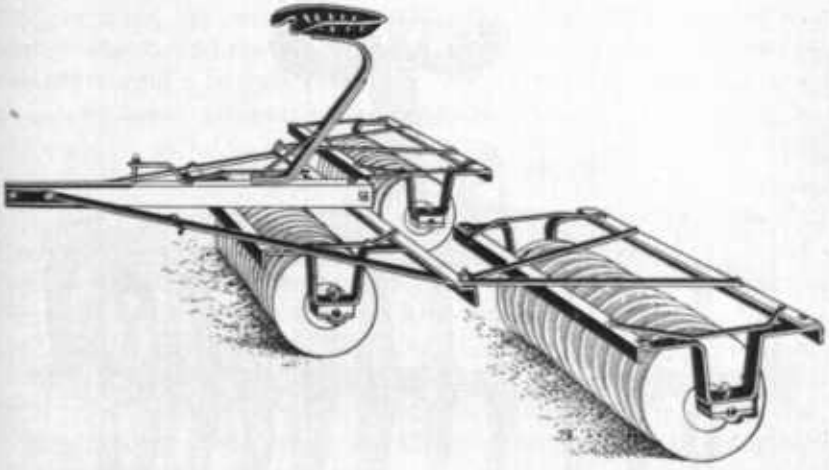

FIG. 8.—A corrugated roller used to pack the lower part of the furrow slice.

can be cleaned reasonably well in this way by two years' summer fallowing, raising one crop of wheat in the meantime.

A few farmers make a practice of disking land in the early autumn that is to be fallowed the next summer. Were this to become a common practice it would be a valuable addition to the present methods. By early fall disking weed seeds are covered and caused to germinate, the soil is put in better condition to take the winter rain and snow, and stubble is covered, or partially so, and its decomposition hastened. The soil usually works much better in the spring, and less surface cultivation is needed before plowing.

(5) **Subsurface packing.**—In addition to the last method of summer fallowing described, two special implements are used in different parts of the country for settling and packing the lower portion of the furrow slice. One of these implements is a corrugated roller, the

corrugations of which are sharp and wedge shaped (fig. 8). The bevel of the corrugations reaches from the outer rim to the large axle to which the corrugations are attached. This roller has been used in the vicinity of Wasco, Oreg., for a number of years. The other implement, the subsurface packer, has been introduced more recently. It consists of a series of wheels upon a long shaft (fig. 9). The rims of these wheels are wedge shaped.

As explained before, land that has just been plowed is loose and open, containing many air spaces. This open condition permits the air to circulate quite freely in the soil, which dries it out quickly. While it is desirable that the air should enter the soil and that noxious gases arising from the decomposition of organic matter should escape, there is little danger of getting the lower portion of the soil turned by

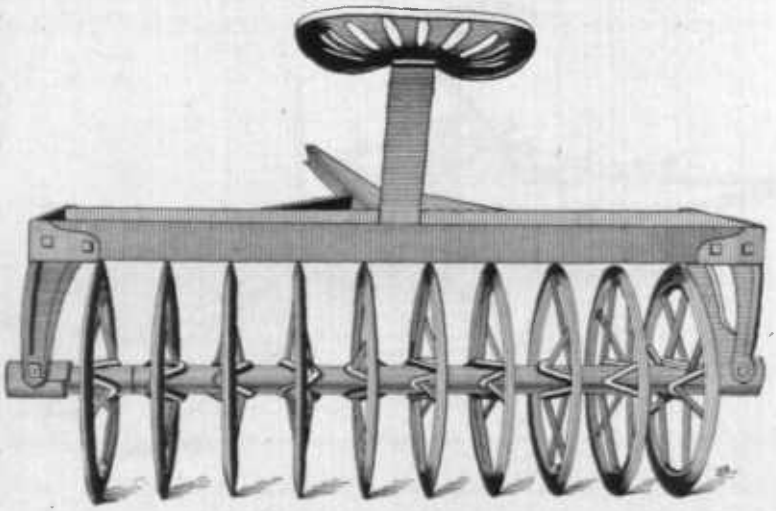

FIG. 9.—A subsurface packer.

the plow into a too compact condition in at least the major portion of the Columbia Basin. In fact, summer fallow land usually dries out as deep as it is plowed because it is too open. In summer fallowing an effort should be made to get the bulk of the soil that has been turned by the plow, especially the lower portion, pulverized and packed so closely that the air will circulate in it very slowly.

When the corrugated roller or the packer is used on the summer fallow land it closely follows the plow. It should never be used when the soil is wet, for the packing will cause the soil to run together. But if the plowing has been done when the soil breaks up in a mealy, granular condition, the mashing of these wedge-shaped surfaces into the soil fills up the air cavities and presses the soil granules together without uniting them. This causes the air to circulate in the soil

very slowly, and in this way the amount of moisture lost by evaporation is greatly reduced. Water passes from a soil that is moist and in this mealy, granular condition into a dry soil very slowly. In order to save the greatest amount of moisture, then, it should be the aim to dry the surface soil just as quickly as possible after plowing and packing. This is done by stirring the surface, usually with a common tooth harrow. The surface is then kept dry by frequent surface cultivations. In conserving moisture it is also very essential that the surface be stirred after each rain that wets down to the moist soil or forms a crust on the surface.

The following instance illustrates the value of subsurface packing in the Columbia Basin:

Mr. D. Buchanan summer fallowed 400 acres near Ritzville, Wash. With the exception of running the packer over 70 acres, the entire field received the same treatment. The whole field was sown to winter wheat. At harvest time the 70 acres outyielded the remainder of the field 5 bushels per acre. The corrugated roller has given about the same results in eastern Oregon.

TILLAGE FOR SPRING CROPS.

Tillage for spring crops is quite uniform throughout the Columbia Basin. The plowing is usually done in the spring as early as conditions of the soil and weather will permit. Too often the plow runs the same depth year after year, both when plowing summer fallow land and for spring crops. This causes a hard crust or false hardpan to form just under the plow furrow. Careful farmers prevent this crust from forming by varying the depth of plowing from year to year.

In addition to the plowing, the tillage given for spring crops usually consists of sowing the seed with a disk drill and harrowing the land twice. With no more cultivation after plowing than this, it is safe to say that the lower two-thirds of the soil turned by the plow is never pulverized or sufficiently compact. It is too loose and open; the air circulates through it rapidly and it dries out quickly.

The following illustrates the value of thoroughly settling and packing the soil when preparing it for spring crops:

Two farmers living in Lincoln County, Wash., had adjoining fields, with a road running between them. They plowed at the same time and at the same depth. They also sowed the same variety of wheat on the same day. One of them harrowed ten times as much as the other and harvested 27 bushels per acre to his neighbor's 17.

Where the corrugated roller and subsurface packer have been introduced, they are used for settling and packing the soil for spring crops. Farmers in eastern Oregon who use the corrugated roller say that their seed germinates much better and that the yield is several bushels

more per acre when they use the roller just after drilling in the grain. They also say that it would pay to use this implement even though there were no increase in the yield. This is because the ground is so much firmer at harvest time, which enables them to cut the grain so much more easily and cheaply.

If neither the corrugated roller nor the subsurface packer is available the disk harrow is sometimes used instead. It is set perfectly straight and weighted to make it cut deeply. Used in this way it does very effective work in settling and packing the bottom of the furrow slice.

There is considerable fall plowing done for spring crops. It is generally conceded that better yields are secured from fall plowing than from spring plowing, provided the land is reasonably clean. There are several reasons for this. Soil left rough and porous as it comes from the plow holds the snow better and takes the snow and rain much better than land that is unplowed. By seeding time in the spring the winter rains have settled the soil sufficiently to form a good, firm seed bed. In other words, the winter rains put the bottom of the furrow slice in practically the same condition as does the subsurface packer or the corrugated roller. When in this condition there is a very much better upward capillary movement of the moisture than is usually secured from spring plowing. Again, by plowing in the autumn the stubble and other trash on the surface of the ground are covered and given a better chance to decay. Getting the stubble well covered is an important item, and to accomplish this the jointer or a chain is often attached to the plow beam. When the land to be summer fallowed is reasonably clean, some plow in the fall for these same reasons.

VARIETIES OF WHEAT GROWN.

There are many varieties of wheat grown in the Columbia Basin. The following list includes practically all of them: Little Club, Salt Lake Club, Chili Club, Crooked-Neck Club, Australian Club, Red Chaff, Jenkins, Early Wilbur, Bluestem, Red Allen, White Elliott, Scotch Fife, Sonora, Rosaro, Klondike, Gold Coin, White Tuscan, Mediterranean Red, German Red, May King, Wolf Hybrid, Canadian Hybrid, Genesee Giant, White Amber, Red Russian, Jones Fife, Arcadian, Fortyfold, Turkey Red, and several varieties of durum wheat.

While only a few varieties of wheat are usually found in any particular locality, these are quite well distributed throughout the Columbia Basin. There is considerable variation in their yield, in their milling qualities, and in their adaptability to local conditions. So many kinds of wheat with their variable milling qualities thrown upon the market make a very unsatisfactory condition to all concerned. Could this list of wheats be reduced to six or eight of the best varieties

the conditions would be much more satisfactory. The varieties would then become standardized. The miller would know what he was buying, and the producer what he was selling.

To test and study all of these varieties of wheats sufficiently to determine which are best adapted to the arid, semiarid, and humid sections of the Columbia Basin is no small undertaking. So many of them have been grown for so short a time and in such small quantities that it is out of the question to pass reliable judgment upon them. Therefore, in the pages that follow only those varieties will be discussed that have been grown long enough and in sufficient quantities to warrant an estimation of their worth.

In selecting the most profitable wheat to grow, it is not always possible to satisfy both the farmer and the miller. A wheat of poor milling qualities may be a heavy yielder, and for that reason very profitable to the producer. What is said regarding the milling qualities of the wheats under consideration is based largely upon the answers to a circular letter sent to the millers of the Pacific Northwest. In judging the milling qualities of any variety of wheat the locality in which it is grown must be considered. Two samples of any variety of wheat, one grown under arid and the other under humid conditions, will differ very materially in milling qualities.

SPRING WHEATS.

Spring wheats are raised throughout the Columbia Basin. In the most humid part of the region, the eastern portion, spring varieties of wheat are sown in both autumn and spring. When sown in the fall on summer fallow land they are frequently winterkilled.

In that portion of the region with less than approximately 18 inches of rainfall (see rainfall map, p. 9), the prevailing methods of summer fallowing do not retain sufficient soil moisture to germinate early-sown wheat before the fall rains come. By referring to the table showing the monthly rainfall distribution (p. 10) it will also be seen that in the arid localities the fall rains do not come until November, while in the humid section they begin in the early autumn. In the semiarid section, between the arid and humid, the fall rains are uncertain.

In the arid section considerable wheat is sown during the fall in the dry soil. The grain then lies in the soil until the late rains come, when sufficient moisture can usually be relied upon to germinate the seed and sustain the young plants. Mr. W. W. Weatherford, of Gilliam County, Oreg., has farmed with approximately 10 inches of rainfall for twenty-five years. He always sows his wheat in the fall in the dry soil. Three times during the twenty-five years he has had to reseed. This was not because his grain germinated and then died from lack of moisture, but because it was winterkilled.

In the eastern portion of the region, under humid conditions, little difficulty is experienced in getting good stands of fall-sown wheat.

In the semiarid section, where the fall rains are uncertain, there is much greater risk in sowing wheat in the early autumn under the present methods of summer fallowing. It sometimes happens that just enough rain falls to germinate the seed, after which dry weather prevails. The young plants then die from lack of sufficient moisture for growth. Because of these difficulties in raising winter wheat much of the summer fallow land in the semiarid belt is not sown in the fall. It lies over until spring, when it is sown to spring wheat.

The following are some of the most important varieties of spring wheat now being grown.

Little Club.

The Little Club was probably one of the first varieties of wheat brought into the Columbia Basin. From its introduction until the present time it and Red Chaff have been the leading wheats grown along the foothills of the Blue Mountains. For years it was the leading wheat of the Palouse country. Until the last few years it was practically the only wheat grown in much of eastern Oregon. Although it is often sown in the fall it will not stand the winters nearly so well as some of the true winter varieties.

The Little Club wheat has a stiff straw, and unless the growth is very rank it will stand a long time after it is ripe without falling. It does not shatter easily. It is, therefore, admirably adapted to harvesting with the "combine"[a] and header. The Little Club variety yields well, and in its territory, the moist eastern portion of the Columbia Basin, few wheats are its equal. It is a standard wheat on the market.

Red Chaff.

The Red Chaff and the Little Club are very similar wheats. They are adapted to practically the same conditions and territory. In some localities the farmers prefer Red Chaff, while in others Little Club is the favorite. There seems to be little difference in their milling qualities. Some of the millers place Red Chaff first, while Little Club is preferred by others.

Jenkins.

The Jenkins belongs to the Club type of wheats. It has red chaff, a stiff straw, a club head, and a grain very similar to that of the Little Club variety. In parts of eastern Oregon under very dry conditions it has largely replaced the latter during the last ten years. Under

[a] A combined harvester and thrasher, a machine much used on the Pacific coast.

these dry conditions it is said that the Jenkins variety yields a little more and stands the winters and hot weather a little better than the Little Club wheat.

Early Wilbur.

The Early Wilbur also belongs to the Club type of wheats. It is about ten or twelve days earlier than the Jenkins and the Little Club varieties. Because of its earliness it usually fills and tests well when later wheats are shriveled by the dry, hot weather. Those growing this wheat speak of it very highly as a spring wheat. When sown in the fall it is easily winterkilled. When grown with about 10 inches of rainfall it is said to outyield the Jenkins and the Little Club varieties one year with another. When the rains continue late in the spring the Jenkins wheat yields the best. For the very dry localities the Early Wilbur variety should prove a very valuable wheat.

Bluestem.

Where the annual rainfall is less than 18 or 19 inches the Bluestem is usually the leading variety of spring wheat. There are possibly two exceptions to this, namely, in the vicinity of Waterville, Douglas County, Wash., where Red Allen is in the lead, and in parts of eastern Oregon where the Club varieties—Little Club, Crooked-Neck Club, Jenkins, and Early Wilbur—predominate. Where the annual rainfall is more than 20 inches it usually grows too rank and tall, and falls down.

The Bluestem variety is sown in both autumn and spring. It stands the winters poorly, however, when compared with the true winter varieties. It has a straw of good length, does not shatter easily, stands the dry hot weather well, and always commands a premium of from 2 to 3 cents over the Club varieties. The Bluestem contains a high percentage of gluten, and when milled produces a strong flour of superior white color. It is therefore a deservedly popular wheat with the millers.

WINTER WHEATS.

The winter varieties of wheat are grown throughout the Columbia Basin. In the arid and semiarid sections, where difficulty is experienced in getting satisfactory stands of fall-sown wheat on account of the lack of moisture, the spring varieties predominate. When a good stand of winter wheat is secured it is generally conceded that it will outyield spring wheat several bushels to the acre. Where the rainfall is sufficient to germinate early fall-sown grain, summer fallow land is always sown in the autumn.

The following are the principal varieties of winter wheat now being grown.

Red Russian.

For several years the Red Russian variety has been the leading winter wheat in eastern Spokane and eastern Whitman counties, Washington, and in Latah County, Idaho. It stands the winters very well, does not shatter easily, and yields satisfactorily. Because of the heavy growth of stems the Red Russian variety is one of the best wheats that has been found to crowd out wild oats. The milling qualities of this wheat are very poor, and it usually sells for 3 cents less than the Club variety and for 5 cents less than the Bluestem wheat. For these reasons its acreage is decreasing.

Jones Fife.

At the present time Jones Fife wheat has a larger acreage in the dry portions of the country than any other winter wheat. The territory in which it is grown is practically the same as that of the Bluestem variety. It is grown very little where the rainfall is heavy. While this wheat is hardy and stands the winter well, many consider it inferior to Fortyfold or Turkey Red in this respect. It shatters very easily, and the heads are long and drooping. The reel slats of the header push many of these drooping heads down and when cut off by the sickle they drop to the ground and are lost. As an export wheat, Fife rates with the Club varieties. It is not their equal as a milling wheat, and its flour is largely used for the export trade. When the Fife freezes out and it is necessary to reseed with the Bluestem variety in the spring some of the Fife wheat usually survives, giving a mixed crop. The mixture sells for Fife prices.

Fortyfold.

Of all the wheats grown in the Columbia Basin few, if any, are better adapted to the entire region than the Fortyfold variety. It stands the winters as well as any wheat grown, with the possible exception of the Turkey Red. The Fortyfold variety is very early, and escapes much of the hot weather in the dry localities that later sorts have to endure. Its earliness is also a great advantage in the eastern portion of the region, where considerable grain is often damaged by the fall rains. Being from 10 to 14 days earlier than other varieties, harvest starts that much sooner. This gives a better chance to care for the grain before the fall rains begin. The Fortyfold variety yields well, but shatters easily. During the past season (1906) this variety sold for the same price as the Bluestem wheat. With but few exceptions the millers who grind this wheat generally agree that it stands between the Little Club and Bluestem varieties in milling qualities.

Turkey Red.

The Turkey Red variety is a hard winter wheat, adapted to about the same territory as Bluestem, i. e., localities with less than 18 inches of rainfall. It probably stands the winters the best of any wheat grown in the Columbia Basin, and unlike most true winter wheats shatters very little. The stems have but little foliage, and for this reason it can be sown thicker than most wheats. When thin on the ground it is inclined to fall, but if thick it stands up quite well. Where the rainfall is more than approximately 18 inches the growth is often too great for the strength of the straw, and it then falls down. However, it is sometimes sown with good results on fall-plowed stubble land. Some object to the Turkey Red variety because it is bearded. Men do not like to work in it. Header horses are usually fed on headed wheat, and the beards make their mouths sore. If the Turkey Red variety is the most profitable wheat to grow, enough of some other variety can be grown to produce feed for the horses.

It is the opinion of experienced growers that the Turkey Red outyields the Jones Fife variety from 4 to 8 bushels to the acre. It is very heavy and seldom tests below No. 1. In milling qualities it stands next to the Bluestem variety. The bran is thin, and some millers say it produces more flour per bushel than the Bluestem wheat. When made from wheat of good quality the flour is of excellent strength, and many of the mills are now grinding it for the bakers' trade. The Turkey Red sold for 1 cent less than the Bluestem variety during the season of 1906.

There is quite a tendency in this wheat for the kernels to become starchy. Perfect kernels are hard, horny, and flinty. When they become yellow they contain less protein and more starch. The cause of this retrogression is not well understood and presents an interesting subject for investigation. For seed it is probably safest to plant wheat containing as few yellow, starchy kernels as possible.

THE PERMANENCY OF THE SINGLE-CROP SYSTEM OF FARMING.

That the wheat lands of the Columbia Basin will produce cereal crops exclusively for an indefinite time without the yields declining is a very general opinion among the farmers of the region. But history is against this opinion. Bountiful harvests for a number of years while the soils were new and then a decline in the yields have been the history of all agricultural regions that have followed a single-crop system. A few examples of this are cited:

Wheat was produced quite successfully in central New York for something like forty years. During the latter part of that period the yields began to decline, and at the end of another twenty years they were so low that exclusive wheat growing became unprofitable.

Ohio, Indiana, Illinois, and Iowa have each in turn repeated the history of New York. The soils of these States were productive in the beginning, and it required forty, fifty, or sixty years for the single-crop system to materially reduce the yields.

But it is not necessary to go to the Eastern States to cite examples of soils whose productiveness has been greatly reduced by the same system of farming that is being practiced in the Columbia Basin. The Willamette Valley, Oregon, was settled about sixty years ago, and until recently wheat was the principal product of the farm. In the beginning large yields were secured, but the soil soon became foul with wild oats and other weeds. The summer-fallow system was then adopted. The yields gradually declined on land that produced wheat continually, until an average as low as 10 or 12 bushels to the acre was reached. These low yields are driving many to other types of farming, and the Willamette Valley now gives promise of becoming one of the leading dairy sections in the United States. The Sacramento Valley, California, is another excellent example. This valley was settled some fifty years ago, and has produced wheat by the summer-fallow system during practically all this time. The yield has steadily declined, until now it is probably as low as 10 bushels per acre.

With due consideration of these examples of agricultural history, how can the wheat lands of the Columbia Basin be expected to maintain their productiveness indefinitely? Are not signs to the contrary manifesting themselves in parts of the country at the present time? Twenty years ago much of the Palouse country gave as large average yields of spring wheat, producing crops every year, as are now secured from winter wheat grown by the summer-fallow system. The virgin soils of the Palouse country and the foothills of the Blue Mountains were mellow and friable, with little inclination to run together. As stated in the foregoing pages in discussing summer fallowing, many farmers think it now necessary to plow the summer fallow so late that the soil will break up in large chunks, this rough, cloddy condition largely preventing the soil from running together during the winter. Now this means simply that this system of farming—summer fallowing and raising nothing but cereal crops—is continually using up the decaying vegetable matter in the soil faster than it is being added. This gradually renders the soil more lifeless and more inclined to run together.

Another source of great loss to the soil is the practice of burning the stubble before plowing. Where the stubble is heavy, it is difficult to plow under, and the easiest way to get rid of it is to burn it. Many farmers do not appreciate the influence decayed vegetable matter (stubble, manure, etc.) has upon the texture and water-holding capacity of the soil. For these reasons these farmers burn their stubble before plowing.

Depleting the soil of its vegetable matter in this way is a slow process, and it is difficult to predict how long it will be until diminished yields force upon the country other types of farming. In the drier localities the yields of wheat seem to be holding up remarkably well. In fact, many claim they have increased. This may be due, first, to better methods of summer-fallow tillage, whereby a greater amount of soil moisture is conserved. In the second place, it may be due to an increase of humus in the soil. The dry soils of the Columbia Basin were not rich in humus when first brought under cultivation. When the grain is cut with a header, all of the straw possible is left upon the ground. It may be that the plowing under of the stubble is adding organic matter to the soil faster than it is being used. At any rate, it is very evident that the drier portions of the Columbia Basin will stand this type of farming much longer than localities near the mountains, where the rainfall is heavier.

CONCLUSIONS.

The best method of summer fallowing in the Columbia Basin consists in disking and harrowing in the early spring before plowing, packing the subsurface immediately after plowing, and following this by sufficient surface cultivation to retain moisture and keep the weeds under control. While this method is not in general use, it is becoming more popular and has been practiced long enough to demonstrate its superior value. Men who practice this method estimate that their yields of wheat are about 25 per cent greater than those obtained by summer fallowing in the ordinary way. The average yield of wheat in the State of Washington during the year 1906 was 20.4 bushels per acre. This will represent approximately the yield for the Columbia Basin. If it is true that this method increases the yield 25 per cent, the average yield of wheat for the entire region can be raised 5 bushels per acre. By adopting this method of summer fallowing it is possible to retain sufficient moisture throughout much of the semiarid section to germinate wheat at any time it may be sown in the fall. This will make it possible to grow winter wheat over a large area that now produces spring wheat. During the year 1906 the average yield of winter wheat in the State of Washington was 4½ bushels more than that of spring wheat. In addition to increasing the average yield of wheat in the Columbia Basin about 5 bushels per acre, it will be seen that better tillage will further increase the yield 4½ bushels per acre over much of the semiarid section by making it possible to grow winter wheat instead of spring wheat. Hence the importance of the general adoption of this method throughout the Columbia Basin.

In the central portion of the Columbia Basin, where the rainfall is

less than 6 inches, wheat can not be successfully produced without irrigation. In extending the area of winter wheat out into the semiarid and arid sections a point will be reached where it will not be possible to conserve sufficient moisture to germinate grain before the fall rains come. When the tillage has been thorough and sufficient moisture has been retained to germinate the seed, the grain is planted quite deeply. When the seed germinates, the young roots are then in contact with moist soil. This enables the young plants to survive until the fall rains come.

Better preparation of the soil for spring crops, especially the use of implements for settling and packing the bottom of the plow furrow, would materially increase the yield of all cereal crops when the land is plowed in the spring before it is sown. During the summer of 1906 the writer saw a field of oats at Grass Valley, Oreg., a portion of which had been packed with a corrugated roller. When seen the oats were nearly ripe. The stand and growth of the oats were very much better upon the rolled portion of the field.

If more intensive methods of tillage are to be adopted, either the size of the farms must be decreased or their equipment increased. Generally speaking, the farmers of the Columbia Basin attempt to till more land than can properly be handled with their equipment.

Too many varieties of wheat are now produced in the Columbia Basin. All of them should be thoroughly tested in the arid, semiarid, and humid sections to determine which are most profitable to grow under the three conditions. The best varieties should then be improved by selection.

The farmers as a whole will secure better results by confining themselves to a few varieties of wheat. Of the spring varieties, the Little Club and the Red Chaff are best adapted to the humid sections and the Bluestem to the arid and semiarid conditions. The Early Wilbur is a new wheat, but gives strong indications of considerable value in the arid section because of its earliness.

Of the winter varieties the Turkey Red easily stands first for the arid and semiarid sections. When the grains are hard and horny it is a very superior milling wheat. On account of its tendency to become starchy it may be necessary to occasionally ship in seed wheat from Kansas and Nebraska.

The Fortyfold variety is adapted to the entire region. It stands the winters admirably, and its earliness gives it an advantage in both the dry and the humid sections. It yields well, and when grown under arid and semiarid conditions it possesses very good milling qualities. Like all other wheats in the Columbia Basin, its milling qualities are not so good when grown under humid conditions.